Regional HOT Lanes Network Feasibility Study

Phase 3

FINAL SUMMARY REPORT

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Metropolitan Transportation Commission

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Ver6

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1. BACKGROUND

Purpose of the Study

MTC is examining options for developing a network of high-occupancy/tolled (HOT) lanes for the Bay Area. There are currently no HOT lanes operating in the Bay Area, although they have been used successfully in southern California and in other parts of the country. There is reason to believe, based on ongoing studies and evaluations of Bay Area HOT lanes scheduled to open within the next year or two, that HOT lanes could generate substantial user benefits in the Bay Area through a combination of more efficient use of existing HOV lanes and more rapid implementation of new HOV/HOT lanes through the use of toll revenues generated by the HOT lanes. The scope of the potential network is shown in Figure 1.

MTC's analysis of this concept is being conducted in phases, as described in the next section.

Study Phases

Phase 1

Phase 1 of the MTC HOT Lanes concept study begun in early 2006 examined the feasibility of HOT lanes for the regional network, both as conversions from existing HOV lanes and as extensions to the current HOV network. This study found feasibility for many Bay Area corridors totaling more than 400 centerline miles. Scope activities examined the institutional, financial and technical merits of implementing a HOT lane system, and included costs and revenue estimates.

Phase 2

Phase 2a of the study further advanced the concept by defining the Regional HOT network, assessing general feasibility, defining a "full feature" design approach preferred by Caltrans District 4 and phasing, developing preliminary cost estimates for general categories of HOT lane projects (conversions of existing lanes, widening towards the median, widening towards the outside shoulders, etc.) and by making preliminary assessments of potential revenues.

Phase 2b then defined a “Rapid Delivery” design approach and phasing, and revised the revenue, cost projections and financing analysis accordingly. The Rapid Delivery approach is consistent with design approaches in Southern California and recent facilities in Seattle and Minneapolis. Although the Rapid Delivery design approach was not considered as part of Phase 3, MTC remains interested in pursuing this design approach in areas where the alternative design approaches evaluated in Phase 3 are infeasible or undesirable due to physical or environmental impacts, or result in extreme increases in cost.

Phase 3

Phase 3 of the study, findings of which are contained in this summary report, is intended to apply Caltrans District 4 design guidance to test how well HOT lane access concepts would work in specific corridors. These findings help add a higher level of accuracy to earlier cost estimates that were based on broader assumptions and did not account for specific site conditions along candidate corridors. These still represent planning-level estimates that will be further refined as projects proceed along the project development process.

Related Studies

In addition to MTC, the HOT lanes concept is being viewed with interest by other agencies both within the Bay Area and throughout the state:

- Caltrans is sponsoring the development of a California Express Lane Business Plan. The Business Plan is meant to provide a framework to guide the future development and operation of the Express Lane network and inform decisions regarding design, operations, and policies that govern these facilities. Caltrans is also the owner/operator of all HOV lanes and affected routes where HOT lanes would be located.
- Under existing legislative authority, the Sunol Smart Carpool Lane Joint Powers Authority is developing a HOT lane on a 14-mile southbound section of I-680 between SR-84 and SR-237. When the lane opens in 2010, it will be the first HOT lane in northern California. The Sunol HOT lane will be a buffer-separated limited-access facility that will provide the first test of the type of access point that Caltrans District 4 has indicated it would like to see in the Bay Area.

- The Alameda County Congestion Management Agency (ACCMA) is developing HOT lanes on I-580 as the second Alameda County HOT authorized under existing legislation. Current plans call for an 11-mile eastbound HOT lanes from east of the I-580/I-680 interchange to the Altamont Pass, opening in 2010/2011. The 13-mile westbound HOT lane is planned from the Altamont Pass to west of the I-580/I-680 interchange, opening in 2012/2013.
- The same legislation authorizes the Santa Clara Valley Transportation Authority (VTA) to develop and operate a HOT lane program on two corridors. VTA has conducted a feasibility study for the introduction of HOT lanes in Santa Clara County, with the original plan to implement the lanes on portions of SR-85 and US-101. The project is now in the preliminary engineering stage. The VTA board subsequently approved the development of HOT lanes on the SR-237/I-880 HOV connector, SR-85 and US-101.
- VTA and the ACCMA are both exploring the provision of two HOT lanes in each direction on SR-85, US-101 and I-580. This approach is somewhat different from the single HOT lane facilities assumed on I-680 Sunol. Due to perceived constraints throughout the rest of the region, no analysis was made of this approach in the course of Phase 3 studies. (Dual directional HOT lanes, as currently envisioned by VTA and reviewed by Caltrans, would not have transition lanes at access points, since the second HOT lane will enable other users to maneuver around entering and exiting vehicles.)

The study team has been in close contact throughout this study with the staffs working on these related projects.

The HOT lane network subject to analysis in this study is shown in Figure 1, and includes identified corridors in seven area counties.

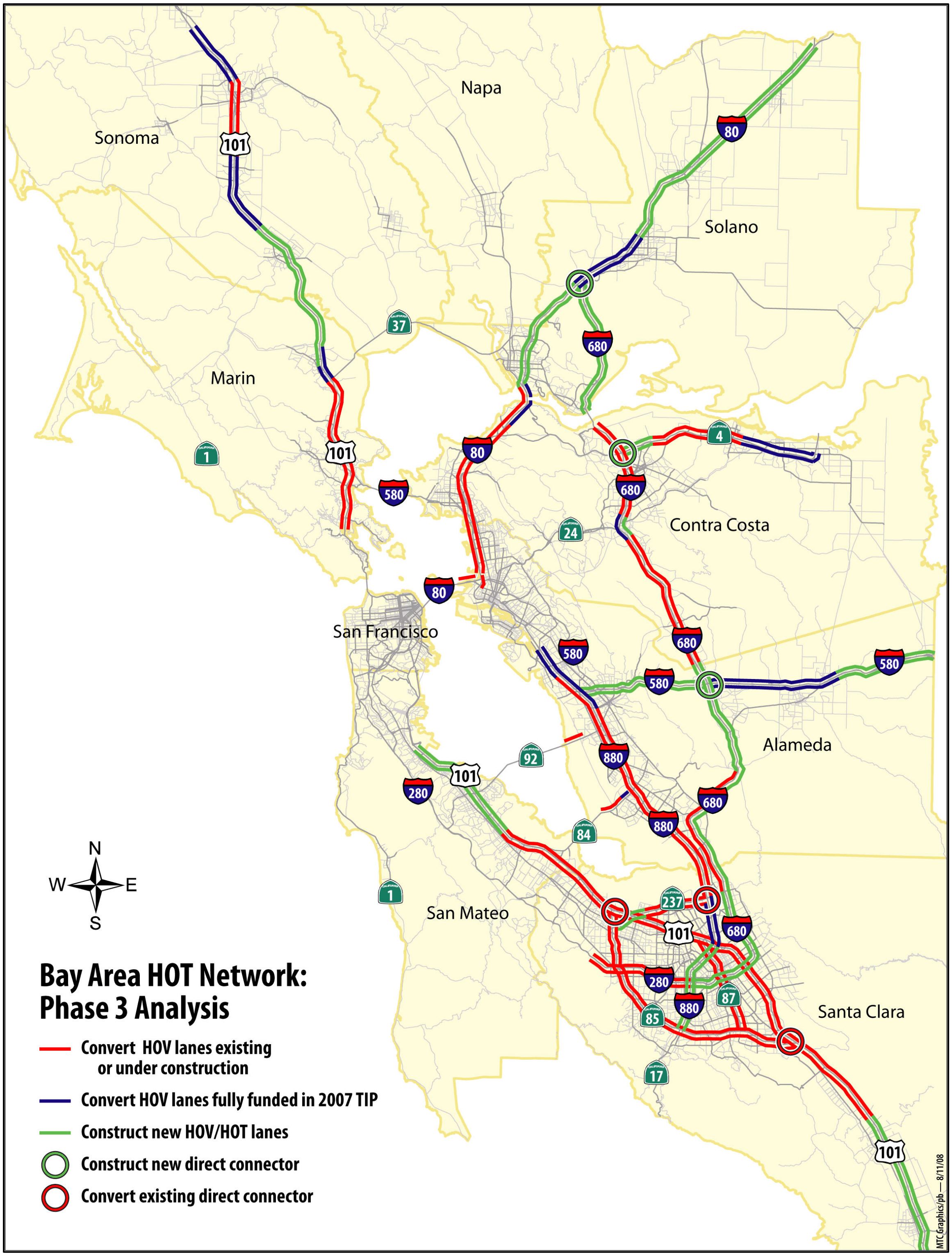

Figure 1: Potential HOT Lane Network

2. DESIGN GUIDANCE

Full Featured Design Approach

The following presents Caltrans District 4's preferred design components for contiguous single-lane Bay Area HOT facilities, either converted from HOV lanes or added in freeway corridors without HOV lanes. This guidance was developed through meetings with Caltrans District 4 and the California Highway Patrol (CHP) and builds on prior work completed for the 1-680 Express Lane project as well as past lessons learned from the HOV system.

- HOT lanes will be physically separated from adjacent lanes through a painted buffer and operate 24 hours daily (no longer operating part-time as is the current HOV operating policy). The painted buffer would typically be 2 feet wide.
- HOT lanes will have separate designated ingress and egress zones to aid in tolling and enforcing the lanes.
- Transition lanes will be provided as part of each ingress or egress area to allow for the orderly diverging and merging of traffic to and from the HOT lane (See Figures 2 and 3).

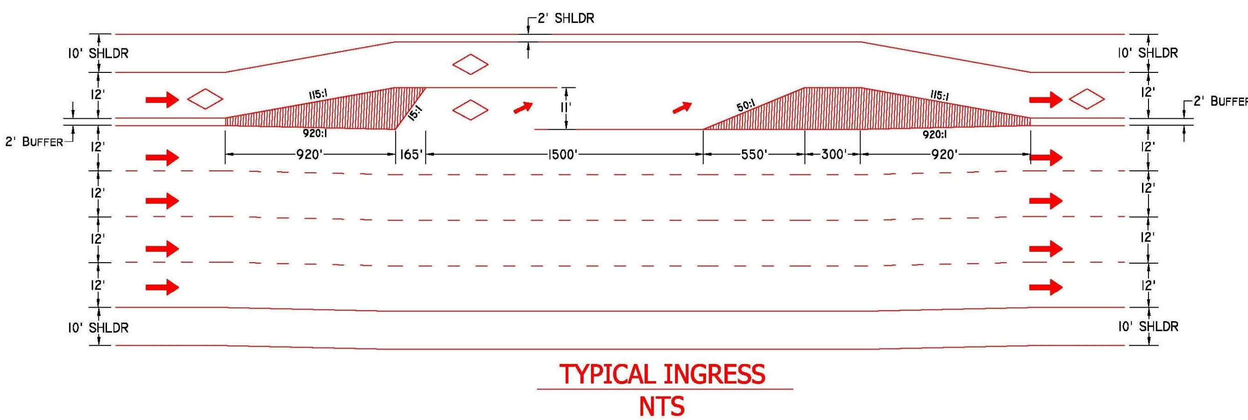

Figure 2: Example Ingress Zone with Transition Lane

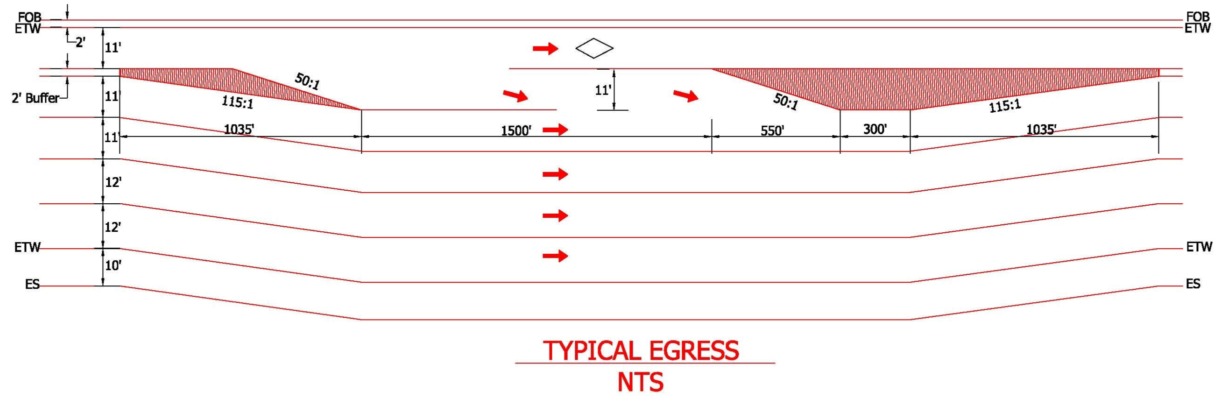

Figure 3: Typical Egress Point for HOT Lane

- In the vicinity of designated ingress and egress areas, minimum weaves per lane of 200m (600 ft) per mainlane weave upstream and downstream of respective ingress and egress location which is reflected in the current Caltrans HOV Guidelines. The application of applying weaving guidance is shown in Figure 4[1].

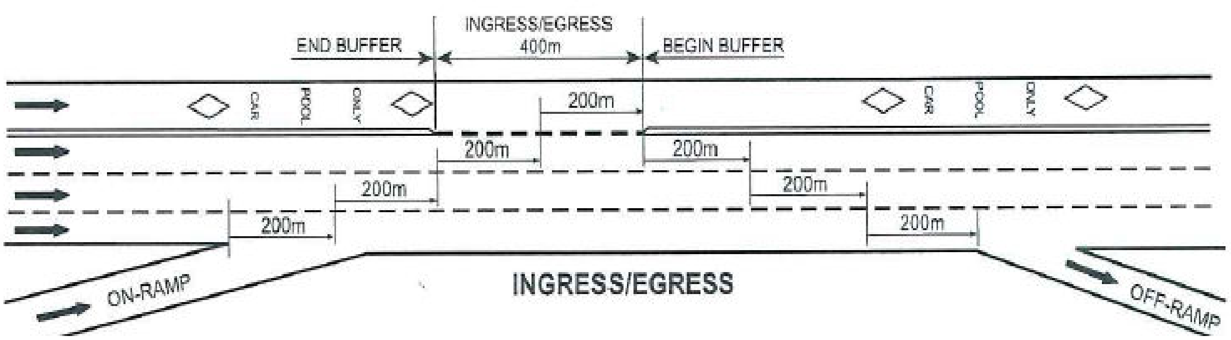

Figure 4: Minimum Weave Distances Associated with Locating Ingress/Egress

- For entrance ramp to the HOT lane, from the nearest upstream right side ramp where ramp taper joins the mainlanes to the beginning of the solid stripe leading into the lane.

[1] Source: Caltrans *High-Occupancy Vehicle Guidelines for Planning, Design, and Operations*, August 2003

- For exit ramp from the HOT lane, the distance from where the HOT lane exit ramp stripe tapers to join the left mainlane edge stripe to the right side full ramp separation (e.g., gore point) of the next downstream exit ramp from the mainlanes.

- Where the HOT lane begins, the lane is a lane addition to the left of the existing general purpose (GP) lanes; an existing GP lane does not become a HOT lane.
- Where a HOT lane ends, it is either terminated as a lane drop or extended as a GP lane beyond the HOT lane.
- No traffic channelizers, pylons or other raised "soft" barriers will be considered within the designated buffer area. The CHP is interested in facilities that are self-enforcing, so some form of barrier to keep drivers from weaving across the buffer would be desirable. Other strategies, including strategic placement of overhead readers and cameras to monitor driving behavior, should be considered to discourage buffer crossing.
- The outside shoulder is the preferred enforcement area in all forms of apprehension by CHP, including HOT lane violators.

Common Trade-Offs

Although all projects will need to go through a Project Study Report (PSR) and analysis specific to each corridor, a general approach to potential trade-offs was developed based on meetings with Caltrans, CHP, and the Congestion Management Agencies (CMAs). In locations where all of the above design attributes will not fit within the available right-of-way, the following trade-offs will be applied in the sequence indicated:

1) Based on the current Bay Area design experience, the outside shoulder is the one design feature that should not be universally compromised. Right side shoulders should nominally be 10 feet in width and 14 feet in spot locations to aid in CHP enforcement. At isolated pinch points shoulders may be reduced for short distances. Such pinch points might include long viaducts and overcrossings with columns that preclude full shoulder continuity. There is no universal response to this condition since the PSR and environmental process typically reviews what is acceptable in such settings. No outside or inside shoulders should be considered for any typical sections which are between 4

and 8 feet, because these present major safety hazards to motorists (these may exist as residual widths for isolated pinch points).

2) Outside lanes used by trucks, which are typically the rightmost two lanes, should be 12 feet.

3) HOT and faster GP lanes can be reduced to no less than 11 feet (typically the #1 and #2 HOT and GP lanes). Transition lanes can be no less than 11 feet between HOT and GP lanes at access locations. Trade-offs for lane widths including the HOT lane should work from left to right.

4) The left shoulder next to the median barrier can be reduced from 10 feet to no less than 2 to 3 feet, depending on the location of drainage inlets, columns and other obstructions, and horizontal and vertical curvature.

5) The buffer between the HOT and GP lanes can be reduced to 1.5 feet in isolated locations (but still must accommodate three pavement stripes).

6) Limited reductions below the prescribed widths for lanes, buffers and shoulders around bridge columns are typically acceptable to Caltrans subject to more detailed project studies, so long as the spot reductions are less than about 1000 feet in length.

Description of the Basic Design Approach

At the direction of MTC and the Project Steering Committee, the Phase 3 analysis covered two approaches to developing HOT lanes in the corridor: the "Basic Approach"[2] and the "Revised Full Featured Approach"[3]. The Revised Full Featured Approach would maintain Caltrans District 4 preferred design guidance as described earlier in this chapter. The Basic Approach differs in constrained conditions where it would allow for sub-standard inside shoulders and a reduction of lane widths from the 12-foot standard to 11 feet. Under exceptionally constrained conditions where freeway widening is infeasible due to cost or environmental reasons, the outside shoulder may also fall below Caltrans' 10-foot standard width for short distances.

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[2] This is derived from the approach used in Phase 2 of this study, which assumed full Caltrans designs developed for the I-680 Express Lane project but allows for some substandard shoulder and lane widths.

[3] This is derived from the approach used in Phase 2 of this study, which assumed full Caltrans designs developed for the I-680 Express Lane project but does not include enforcement zones in the inside shoulder, per discussions with CHP and Caltrans.

3. TECHNICAL APPROACH

The main technical thrust of this study was to apply the design guidance described in the previous chapter to a sample of five corridors, and then draw from the analysis of the sample corridors to make conclusions about the network as a whole.

Preliminary Access Plans

A preliminary access plan was developed for each of the sample corridors which helped establish a basis for where access was generally needed. A proxy for approximating demand for access locations was using current interchange ramp volumes, since the subset of users on a HOT lane should closely parallel overall corridor demand and gives an indication of the frequency for access locations. Based on statewide experience for access restricted HOV lanes and national HOT lane experience, a general guide to access frequency was to provide ingress or egress at about five-mile spacing.

This demand-driven approach dictated placement locations; that is, ingress points should be located at a convenient distance downstream of places where large volumes of traffic enter the freeway system, and egress points should be located at a convenient distance upstream of places where large volumes of traffic leave the freeway system. Information on the volume of traffic entering and leaving the freeways was taken from Caltrans' *2007 Traffic Volumes Report*. Beyond this primary consideration several secondary criteria were considered:

- The target average spacing between points was about five miles, based on experience with HOT lane projects in other cities (Houston, Minneapolis, and Denver) that have found that this distance strikes a reasonable balance between user convenience and smooth traffic operations.
- The target maximum spacing is ten miles, with long spacing to be used only for corridors where demand is low for intermediate access.
- No target for minimum spacing was established because in some densely populated areas there appears to be a need to distribute weaving over several access points in order to avoid having excessive volumes at any one point.

- The placement of access points and egress points were considered independently of each other. This was based on Caltrans guidance that access and egress movements should occur at separate locations.

The initial analysis focused on identifying the most desirable locations for access and egress points based on the primary and secondary criteria described above. This analysis is reported in detail in Appendix B.

Analyses of Selected Corridors

Phases 1 and 2 of the HOT Lanes Study developed the parameters of the system in general terms. While these were useful and necessary steps, questions arose as to how well the general concepts could be applied to a regional network that included freeways built in a variety of time periods with differing design standards and passing through areas of very diverse land use patterns. Phase 3 of the study was designed to answer this question by applying the general system concepts to a sample of five specific corridors. The study corridors were selected by MTC in collaboration with the Project Steering Committee to represent different geographical parts of the region, a variety of land use settings, and differing design standards. The five corridors are highlighted in Figure 5:

- I-80 in Solano County from the Yolo County Line to I-680
- I-680 in Contra Costa County from Marina Vista Drive to Livorna Road
- SR-237 in Santa Clara County from I-880 to SR-85
- US-101 in Marin County from North San Pedro Road to Lucky Drive
- I-880 in Alameda County from SR-92 to SR-237[4]

In terms of lane-miles, the corridors totaled to 22% of the full regional network.

For each corridor the study team met with the local CMA and Caltrans staff to discuss existing and planned projects that could have an effect on the proposed HOT lane. The most pertinent projects were existing or planned HOV lanes. However, other projects such as auxiliary lanes and interchange projects were also relevant because they affect the amount of space potentially available for HOT facilities.

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[4] The analysis of this corridor was funded by the Bay Area Toll Authority.

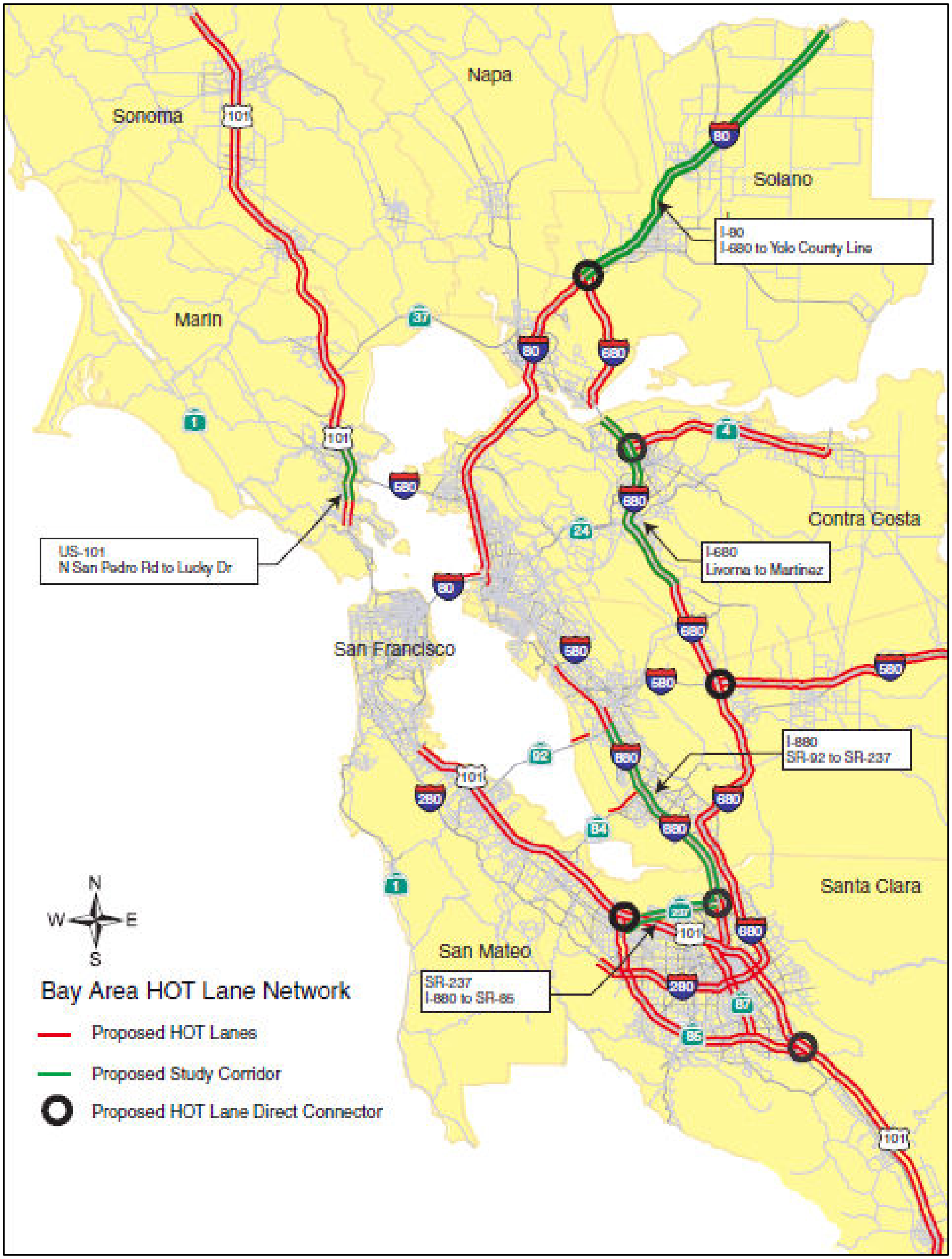


Figure 5: Corridors Selected for More Detailed Analysis

(Note: This map does not represent the full Regional HOT Lane Network now under study. Figure 1, which represents the full regional network, includes additional sections of I-580 and I-880, added following feedback from the Project Steering Committee.)

The next step in the analysis was to determine the approach for introducing a HOT lane into the freeway section under study. In many sections with existing or planned HOV lanes, HOT lanes could likely be introduced by creating a 2-foot buffer between the HOV lane and the adjacent general purpose lanes, and providing appropriate signing and tolling equipment. However, in some extremely constrained areas of the network, even fitting in the 2-foot buffer could be difficult. Where no HOV lane exists or is planned, the HOT lane facility would be developed by adding both a lane and a buffer.

At the direction of MTC and the Project Steering Committee, the analysis assessed two approaches to developing HOT lanes in the corridor, the “Basic Approach” and the “Revised Full Featured Approach”. The primary difference between the two is that in constrained situations the Basic Approach allows for sub-standard inside shoulders and a reduction of lane widths from the 12-foot standard to 11 feet, while the Revised Full Featured Approach would maintain Caltrans design guidance. Under exceptionally constrained conditions where freeway widening is infeasible due to cost or environmental reasons then the outside shoulder may also fall below Caltrans’ 10-foot standard width for short distances.

Next, an examination was performed to determine whether the ingress and egress points identified in the Preliminary Access Plan could fit within the physical constraints of the location. In the event that the point could not be accommodated at the original site, a further analysis was performed to determine whether it could be accommodated by shifting the ingress or egress point to a nearby location. Alternate locations for ingress points were sought downstream of the optimal point while alternate sites for egress points were sought upstream, meaning in effect that traffic wishing to enter or leave the HOT lane would have a longer distance in which to weave across the general purpose lanes. If no alternative site could be found then consideration was given to dropping the proposed site with the assumption that potential users of the point would enter or exit the HOT lanes at other points in the corridor.

The results of these analyses are presented in Appendices C through G. The principal findings reached in the corridor analyses are discussed in Chapter 4 of this report.

Cost Estimates

Once the corridor engineering analyses were complete, several estimates were made of the cost of implementing the plan. The methodology used to prepare these estimates was:

- PB reviewed and revised the unit capital costs determined in a previous phase to reflect recent trends, comments from the local CMAs on actual costs of recent projects, and discussions with Caltrans staff.
- PB then identified major cost elements such as access points and the associated transition lanes, lane-miles of conversion of HOV lanes, and lane-miles of new HOT lanes, in the development of HOT lanes in the study corridor. Special locations that may require major modifications, such as replacement of structures, were also be identified. No right of way costs were included in the estimates.
- In some cases cost estimates were available from other studies for specific improvements that would be needed for HOT lanes, such as replacement of an over-crossing. In such cases the cost estimates were examined and, if found to be relevant, were used in this study either directly or after appropriate modification (such as factoring to reflect current costs and adjusting contingencies to be consistent with this study).
- Based on the unit costs and the identified cost elements consistent with MTC's current HOT lane design criteria, PB then prepared planning-level cost estimates for the development of a HOT lane in the study corridor. Separate estimates were made for the Basic Approach and the Revised Full Featured Approach. Each estimate was disaggregated to show the costs associated with provision of the typical HOT lane section, costs associated with access points, and costs associated with special locations such as major structures that may need reconstruction or replacement.

The details of the cost estimates for each corridor are presented in Appendix I. The cost estimates that were developed on a corridor basis were then used to draw conclusions about the cost of developing the entire network, which is described in the next section.

Extrapolation to Full Network

The costs of developing the full network were estimated by examining the non-studied corridors section-by-section, identifying the closest analogy among the studied corridors, and applying the unit costs to the non-studied corridors. For example, US-101 in southern Santa Clara County is similar to I-80 in Solano County in terms of physical configuration, and so the cost of developing HOT lanes on this portion of US-101 was taken to be similar to the per-mile costs estimated for I-80.

The cost estimates for special locations were not as directly transferable as those of typical locations. Nevertheless, there was a sufficient degree of similarity to enable the study team to develop cost estimates for each corridor, as shown in Table 1 for the Basic Approach and in Table 2 for the Revised Full Featured Approach.

The information in Tables 1 and 2 lead to several important findings:

- The estimated cost per mile varies widely among the corridors. This information can be combined with revenue estimates by corridor to help identify the highest priority corridors in cost/benefit terms.
- Much of the difference comes from the costs associated with special locations. This highlights the importance of maintaining some flexibility in design standards.
- The cost of constructing access points with transition lanes is substantial (36%-41% of total system costs); even leaving aside the indirect costs mentioned earlier.

Corridor			Main HOT Lane			Access Points			Special Locations			Total Corridor Cost ($M)	Average Cost ($M/Mile)	Notes and Comments
Freeway	From	To	Length (Miles)	Cost ($M)	% of Total Cost	Number of Sites	Cost ($M)	% of Total Cost	Number of Sites	Cost ($M)	% of Total Cost			
I-80	Yolo County Line	I-680	59.8	$205.1	58%	20	$146.4	42%	3	$0.3	0%	$351.8	$5.88	About 1/3rd conversion
	I-680	Carquinez Bridge	19.8	$74.4	58%	10	$47.9	38%	8	$5.0	4%	$127.3	$6.43	Eliminate shoulders at 7 overcrossings
	Carquinez Bridge	Central Ave.	26.8	$25.7	39%	8	$38.8	60%	0	$0.7	1%	$65.2	$2.43	All conversion of existing HOV
	Central Ave.	Bridge Toll Plaza	9.0	$8.6	26%	5	$24.3	74%	0	$0.0	0%	$32.9	$3.66	Requires relaxing minimum weave distances at access points
SR-4	Antioch	I-680	37.2	$66.3	45%	12	$67.4	46%	4	$13.1	9%	$146.7	$3.94	About half conversion; includes $75M connector to I-680
US-101 North	River Road	Old Redwood Hwy	34.4	$33.0	35%	8	$62.2	65%	0	$0.0	0%	$95.2	$2.77	All conversion by re-striping
	Old Redwood Hwy	San Antonio	16.8	$68.6	61%	4	$18.1	16%	3	$25.8	23%	$112.6	$6.70	All new lanes; 2 pairs of long bridges need widening
	San Antonio Rd	SR-37	14.0	$54.8	57%	4	$19.4	20%	4	$21.5	22%	$95.7	$6.83	All new lanes; 4 pairs of undercrossings need widening
	SR-37	N. San Pedro	13.6	$24.5	56%	4	$19.4	44%	0	$0.0	0%	$43.9	$3.23	All conversion by widening towards median
	N. San Pedro	Tamalpais	10.0	$10.9	26%	4	$31.1	74%	0	$0.0	0%	$42.0	$4.20	All conversion, mainly through re-striping
	Tamalpais	Shoreline Hwy	4.8	$4.6	100%	0	$0.0	0%	0	$0.0	0%	$4.6	$0.96	All conversion; no access points (short section)
I-680	I-80	Martinez Bridge	23.6	$93.5	80%	4	$18.1	16%	1	$4.9	4%	$116.5	$4.94	All new; wideing towards median
	Martinez Bridge	Livorna	13.5	$16.4	19%	5	$38.9	45%	4	$31.8	36%	$87.1	$6.45	Gap left in most constrained portion; plus $22M structure
	Livorna	Alcosta (CC/ALA line)	22.6	$21.7	22%	10	$77.7	78%	0	$0.0	0%	$99.4	$4.40	All conversion
	Alcosta (CC/ALA line)	SR-84	21.4	$73.8	58%	7	$54.4	42%	0	$0.0	0%	$128.2	$5.99	All new lanes
	SR-84	Calaveras (SR-237)	27.8	$20.5	31%	6	$46.7	69%	0	$0.0	0%	$67.2	$2.42	All conversion (some funded but not yet built)
	Calaveras (SR-237)	US-101	14.2	$58.0	65%	2	$31.1	35%	0	$0.0	0%	$89.1	$6.27	All new lanes
SR-237	I-880	SR-85	17.9	$49.8	32%	12	$93.3	61%	3	$10.5	7%	$153.6	$8.58	HOV lanes already exist for 2/3rds of corridor
US-101 South	Milbrae	Whipple Rd	22.3	$76.9	66%	5	$38.9	34%	0	$0.0	0%	$115.8	$5.19	All conversion
	Whipple Rd	SM/SC Co. Line	13.2	$12.7	35%	3	$23.3	65%	0	$0.0	0%	$36.0	$2.73	All conversion
	SM/SC Co. Line	Cochrane Rd	70.2	$125.9	47%	18	$140.0	53%	0	$0.0	0%	$265.8	$3.79	All conversion
	Cochrane Rd	SR-25	29.7	$121.3	77%	8	$36.3	23%	0	$0.0	0%	$157.5	$5.30	All new lanes
I-280	Magdalena Ave.	Leland Ave.	18.4	$31.1	29%	10	$77.7	71%	0	$0.0	0%	$108.9	$5.92	All conversion
	Leland Ave.	US-101	9.2	$73.8	58%	6	$54.4	42%	2	$0.0	0%	$128.2	$13.94	Includes widening two 800' bridges
SR-85	US-101 north	US-101 south	48.2	$84.2	47%	12	$93.3	53%	0	$0.0	0%	$177.5	$3.68	All conversion
SR-87	US-101	SR-85	18.4	$29.6	49%	4	$31.1	51%	0	$0.0	0%	$60.7	$3.30	All conversion
I-580	I-880	I-680	27.4	$98.3	53%	8	$62.2	34%	5	$23.8	13%	$184.3	$6.73	Requires widening of 2 long and 8 short bridges
	I-680	Greenville	24.2	$23.2	60%	2	$15.6	40%	0	$0.0	0%	$38.8	$1.60	Conversion in EB direction; new in WB direction
	Greenville	San Joaquin Co. Line	17.4	$61.8	57%	6	$46.7	43%	0	$0.0	0%	$108.5	$6.23	All new lanes
I-880	95th Street	Marina	6.2	$21.4	48%	3	$23.3	52%	0	$0.0	0%	$44.7	$7.21	All new lanes
	Marina	SR-92	12.2	$11.7	27%	4	$31.1	73%	0	$0.0	0%	$42.8	$3.51	All conversion
	SR-92	SR-237	37.0	$35.5	28%	12	$93.3	72%	0	$0.0	0%	$128.8	$3.48	All conversion
	SR-237	SR-85	26.0	$79.9	44%	13	$101.1	56%	0	$0.0	0%	$181.0	$6.96	1/3rd conversion, 2/3rds new lanes
SR-92	Bridge approach		1.4	$1.3	100%	0	$0.0	0%	0	$0.0	0%	$1.3	$0.90	All conversion; no access points (short section)
SR-84	Bridge approach		2.8	$2.7	100%	0	$0.0	0%	0	$0.0	0%	$2.7	$0.95	All conversion; no access points (short section)
Direct Connectors	I-80	I-680								$115.0		$115.0		
	SR-4	I-680								$75.0		$75.0		
	I-580	I-680								$325.0		$325.0		
		System Total	771.4	$1,801.2	43%	239.0	$1,703.6	41%	37.0	$652.3	16%	$4,157.1	$5.39	
		Average Cost		$2.3			$7.1			$17.6				
			Miles/access point				3.2							
			Miles/access point per direction (in or out)				6.5							

Table 1: Summary of Costs by Corridor for the Basic Approach (2008$)

Corridor			Main HOT Lane			Access Points			Special Locations					
Freeway	From	To	Length (Miles)	Cost ($M)	% of Total Cost	Number of Sites	Cost ($M)	% of Total Cost	Number of Sites	Cost ($M)	% of Total Cost	Total Corridor Cost ($M)	Average Cost ($M/Mile)	Notes and Comments
I-80	Yolo County Line	I-680	59.8	$276.1	65%	20	$146.4	34%	3	$3.7	1%	$426.3	$7.13	About 1/3rd conversion
	I-680	Carquinez Bridge	19.8	$93.5	64%	10	$47.9	33%	8	$5.1	3%	$146.5	$7.40	Modifications to 1 undercrossing & 7 overcrossings
	Carquinez Bridge	Central Ave.	26.8	$48.2	55%	8	$38.8	44%	0	$0.7	1%	$87.7	$3.27	All conversion of existing HOV
	Central Ave.	Bridge Toll Plaza												Unlikely to be feasible due to physical & enviromental constraints
SR-4	Antioch	I-680	37.2	$80.6	50%	12	$67.4	42%	4	$13.1	8%	$161.1	$4.33	About half conversion; includes $75M connector to I-680
US-101 North	River Road	Old Redwood Hwy	34.4	$61.9	50%	8	$62.2	50%	0	$0.0	0%	$124.1	$3.61	All conversion by re-striping
	Old Redwood Hwy	San Antonio	16.8	$84.9	66%	4	$18.1	14%	3	$25.8	20%	$128.8	$7.67	All new lanes; 2 pairs of long bridges need widening
	San Antonio Rd	SR-37	14.0	$68.3	63%	4	$19.4	18%	4	$21.5	20%	$109.2	$7.80	All new lanes; 4 pairs of undercrossings need widening
	SR-37	N. San Pedro	13.6	$24.5	56%	4	$19.4	44%	0	$0.0	0%	$43.9	$3.23	Conversion; Same as Basic Approach
	N. San Pedro	Tamalpais	10.0	$23.8	28%	4	$31.1	36%	0	$31.3	36%	$86.2	$8.62	Includes widening a viaduct and into a hillside
	Tamalpais	Shoreline Hwy	4.8	$8.6	100%	0	$0.0	0%	0	$0.0	0%	$8.6	$1.80	All conversion; no access points (short section)
I-680	I-80	Martinez Bridge	23.6	$116.3	83%	4	$18.1	13%	1	$4.9	4%	$139.3	$5.90	All new; widening towards median
	Martinez Bridge	Livorna												Unlikely to be feasible due to physical & enviromental constraints
	Livorna	Alcosta (CC/ALA line)	22.6	$40.7	34%	10	$77.7	66%	0	$0.0	0%	$118.4	$5.24	All conversion
	Alcosta (CC/ALA line)	SR-84	21.4	$94.3	63%	7	$54.4	37%	0	$0.0	0%	$148.8	$6.95	All new lanes
	SR-84	Calaveras (SR-237)	27.8	$38.5	45%	6	$46.7	55%	0	$0.0	0%	$85.2	$3.06	All conversion (some funded but not yet built)
	Calaveras (SR-237)	US-101	14.2	$71.7	70%	2	$31.1	30%	0	$0.0	0%	$102.8	$7.24	All new lanes
SR-237	I-880	SR-85	17.9	$62.3	38%	12	$93.3	56%	3	$10.5	6%	$166.2	$9.28	HOV lanes already exist for 2/3rds of corridor
US-101 South	Milbrae	Whipple Rd												Unlikely to be feasible due to physical & enviromental constraints
	Whipple Rd	SM/SC Co. Line	13.2	$23.8	50%	3	$23.3	50%	0	$0.0	0%	$47.1	$3.57	All conversion; almost the same as Basic
	SM/SC Co. Line	Cochrane Rd	70.2	$126.9	48%	18	$140.0	52%	0	$0.0	0%	$266.9	$3.80	All conversion
	Cochrane Rd	SR-25	29.7	$150.0	81%	8	$36.3	19%	0	$0.0	0%	$186.3	$6.27	All new lanes
I-280	Magdalena Ave.	Leland Ave.	18.4	$33.1	30%	10	$77.7	70%	0	$0.0	0%	$110.9	$6.03	All conversion; almost the same as Basic
	Leland Ave.	US-101	9.2	$94.3	63%	6	$54.4	37%	2	$0.0	0%	$148.8	$16.17	Includes widening two 800' bridges
SR-85	US-101 north	US-101 south	48.2	$86.8	48%	12	$93.3	52%	0	$0.0	0%	$180.1	$3.74	All conversion; almost the same as Basic
SR-87	US-101	SR-85	18.4	$33.1	52%	4	$31.1	48%	0	$0.0	0%	$64.2	$3.49	All conversion; almost the same as Basic
I-580	I-880	I-680	27.4	$124.6	59%	8	$62.2	30%	5	$23.8	11%	$210.7	$7.69	Requires widening of 2 long and 8 short bridges
	I-680	Greenville	24.2	$43.6	74%	2	$15.6	26%	0	$0.0	0%	$59.1	$2.44	Conversion in EB direction; new in WB direction
	Greenville	San Joaquin Co. Line	17.4	$78.5	63%	6	$46.7	37%	0	$0.0	0%	$125.1	$7.19	All new lanes
I-880	95th Street	Marina	6.2	$27.3	54%	3	$23.3	46%	0	$0.0	0%	$50.7	$8.17	All new lanes
	Marina	SR-92	12.2	$22.0	41%	4	$31.1	59%	0	$0.0	0%	$53.1	$4.35	All conversion
	SR-92	SR-237	37.0	$88.1	49%	12	$93.3	51%	0	$0.0	0%	$181.4	$4.90	All conversion
	SR-237	SR-85	26.0	$104.0	51%	13	$101.1	49%	0	$0.0	0%	$205.1	$7.89	1/3rd conversion, 2/3rds new lanes
SR-92	Bridge approach		1.4	$2.3	100%	0	$0.0	0%	0	$0.0	0%	$2.3	$1.67	All conversion; no access points (short section)
SR-84	Bridge approach		2.8	$5.0	100%	0	$0.0	0%	0	$0.0	0%	$5.0	$1.79	All conversion; no access points (short section)
Direct Connectors	I-80	I-680								$115.0		$115.0		
	SR-4	I-680								$75.0		$75.0		
	I-580	I-680								$325.0		$325.0		
		System Total	726.6	$2,237.7	50%	224.0	$1,601.6	36%	33.0	$655.4	15%	$4,494.7	$6.19	
		Average Cost		$3.1			$7.1			$19.9				
			Miles/access point				3.2							
			Miles/access point per direction (in or out)				6.5							

Table 2: Summary of Costs by Corridor for the Revised Full Featured Approach (2008$)

A comparison of the cost estimates for the Basic Approach and the Revised Full Featured Approach, as well as the cost estimates from Phases 2 and 2b, are presented in Table 3. In reviewing the costs shown in Table 3 the reader should take note of the following:

- The highway construction market is going through a very volatile period. Caltrans' Construction Price Index rose more in 2004 than it had in the previous fifteen years combined, followed by further rapid increases in 2005. On the other hand, 2007 and 2008 saw sharp drops in construction prices due to crisis conditions in the housing market and cutbacks in government spending. Therefore, although the cost estimates were based on accurate recent information, it is not clear whether this information will be valid going forward. Equally plausible arguments could be made for expecting prices to rise or to fall over the next five years.
- Nevertheless, the cost estimates have value as being indicative in relative terms. In other words, if one corridor is estimated to be twice as expensive to develop as another corridor, that ratio is likely to hold true even if overall statewide prices fluctuate.
- The Phase 3 cost estimates are not directly comparable to those of Phases 2 and 2b of this study, because both the unit costs and the design assumptions have changed. Specifically:
    - Earlier phases used the unit costs prevailing in 2006, while Phase 3 uses 2007 unit costs with some adjustments based on observed conditions in 2008.
    - Phase 3 assumed that all access points would include transition lanes. Phase 2 included costs for only the additional pavement required for transition lanes, but not the other costs associated with accommodating transition lanes. Phase 2b included no transition lane costs.
    - Phase 2 assumed that 14-foot enforcement areas would be required on the median side of all HOT lanes. This assumption was dropped in Phase 3 in light of CHP guidance that enforcement would be on the right (outside) shoulder rather than in the median.

The Phase 3 estimates supersede rather than supplement the previous estimates.

- Note also that there were several corridors where the Revised Full Featured Approach does not appear to be feasible due to high cost, operational problems with weaving traffic, and/or impacts to the surrounding community. No cost estimates were made for these corridors. The system-wide total cost for the Basic Approach thus cannot be directly compared with the system-wide total cost for the Revised Full Featured Approach because the former includes corridors that are missing from the latter.

Corridor			Phase 3 Estimates				Phase 2		Phase 2b	
Freeway	From	To	Basic Approach	Revised Full Featured	Difference	Difference as % of Basic Approach	Full Design	Difference from Phase 3 Full Featured	Rapid Delivery	Difference from Phase 3 Basic
I-80	Yolo County Line	I-680	$351.8	$426.3	$74.5	21%	$520.5	-$94.2	$375.8	-$24.0
	I-680	Carquinez Bridge	$127.3	$146.5	$19.2	15%	$231.5	-$85.0	$199.4	-$72.2
	Carquinez Bridge	Central Ave.	$65.2	$87.7	$22.5	35%	$112.4	-$24.6	$31.4	$33.8
	Central Ave.	Bridge Toll Plaza	$32.9	Unlikely to be Feasible			$43.7		$16.5	$16.4
SR-4	Antioch	I-680	$146.7	$161.1	$14.3	10%	$266.1	-$105.1	$67.3	$79.4
US-101 North	River Road	Old Redwood Hwy	$95.2	$124.1	$28.9	30%	$96.3	$27.9	$109.5	-$14.3
	Old Redwood Hwy	San Antonio	$112.6	$128.8	$16.3	14%	$301.3	-$172.5	$80.1	$32.4
	San Antonio Rd	SR-37	$95.7	$109.2	$13.5	14%	$339.3	-$230.1	$105.5	-$9.9
	SR-37	N. San Pedro	$43.9	$43.9	$0.0	0%	$32.4	$11.5	$13.6	$30.3
	N. San Pedro	Tamalpais	$42.0	$86.2	$44.3	105%	$68.3	$17.9	$10.9	$31.1
	Tamalpais	Shoreline Hwy	$4.6	$8.6	$4.0	88%	$11.4	-$2.8	$4.8	-$0.2
I-680	I-80	Martinez Bridge	$116.5	$139.3	$22.8	20%	$253.0	-$113.7	$179.3	-$62.8
	Martinez Bridge	Livorna	$87.1	Unlikely to be Feasible			$85.6		$44.0	$43.1
	Livorna	Alcosta (CC/ALA line)	$99.4	$118.4	$19.0	19%	$50.7	$67.7	$33.1	$66.3
	Alcosta (CC/ALA line)	SR-84	$128.2	$148.8	$20.5	16%	$184.5	-$35.7	$129.2	-$1.0
	SR-84	Calaveras (SR-237)	$67.2	$85.2	$18.0	27%	$184.5	-$99.3	$30.3	$36.9
	Calaveras (SR-237)	US-101	$89.1	$102.8	$13.7	15%	$40.4	$62.4	$95.2	-$6.1
SR-237	I-880	SR-85	$153.6	$166.2	$12.5	8%	$116.8	$49.4	$56.7	$96.9
US-101 South	Milbrae	Whipple Rd	$115.8	Unlikely to be Feasible			$269.6		$263.8	-$148.0
	Whipple Rd	SM/SC Co. Line	$36.0	$47.1	$11.1	31%	$51.4	-$4.3	$14.7	$21.3
	SM/SC Co. Line	Cochrane Rd	$265.8	$266.9	$1.1	0%	$121.6	$145.2	$76.3	$189.6
	Cochrane Rd	SR-25	$157.5	$186.3	$28.7	18%	$223.2	-$36.9	$149.6	$8.0
I-280	Magdalena Ave.	Leland Ave.	$108.9	$110.9	$2.0	2%	$50.7	$60.2	$23.7	$85.2
	Leland Ave.	US-101	$128.2	$148.8	$20.5	16%	$184.5	-$35.7	$58.6	$69.7
SR-85	US-101 north	US-101 south	$177.5	$180.1	$2.5	1%	$99.9	$80.1	$54.8	$122.7
SR-87	US-101	SR-85	$60.7	$64.2	$3.5	6%	$25.0	$39.3	$20.0	$40.7
I-580	I-880	I-680	$184.3	$210.7	$26.3	14%	None		None	
	I-680	Greenville	$38.8	$59.1	$20.4	53%	$66.9	-$7.8	$63.0	-$24.3
	Greenville	San Joaquin Co. Line	$108.5	$125.1	$16.7	15%	$72.6	$52.5	$76.5	$32.0
I-880	95th Street	Marina	$44.7	$50.7	$5.9	13%	$77.3	-$26.7	$71.0	-$26.3
	Marina	SR-92	$42.8	$53.1	$10.3	24%	$27.4	$25.7	$13.3	$29.5
	SR-92	SR-237	$128.8	$181.4	$52.6	41%	$83.0	$98.4	$38.0	$90.7
	SR-237	SR-85	$181.0	$205.1	$24.1	13%	None		None	
SR-92	Bridge approach		$1.3	$2.3	$1.1	86%	$5.9	-$3.5	$1.5	-$0.2
SR-84	Bridge approach		$2.7	$5.0	$2.3	88%	$12.9	-$7.8	$3.0	-$0.4
Direct Connectors	I-80	I-680	$115.0	$115.0	$0.0	0%	$115.0	$0.0	$115.0	$0.0
	SR-4	I-680	$75.0	$75.0	$0.0	0%	$75.0	$0.0	$75.0	$0.0
	I-580	I-680	$325.0	$325.0	$0.0	0%	$325.0	$0.0	$325.0	$0.0
		System Total	$4,157.1	$4,494.7			$4,825.6	-$347.7	$3,025.4 *	$766.4

Table 3: Estimate of the Cost to Develop the HOT Lane Network

Note: The Phase 3 Revised Full Featured estimate includes 726 miles. Phase 2b and Phase 3 Basic include 771 miles.

*Costs shown here for Phases 2b are in 2006$, compared to the $3.7b in escalated dollars used for the 2009 RTP.

4. PRINCIPAL FINDINGS

The Issue of Consistency

Roads are designed to help drivers make split-second decisions under ever-changing conditions. For safety's sake, it is a fundamental principle of traffic engineering that roadway design be consistent to the extent possible, which is why standards and guidelines for roadway design have been developed. However, consistency as a design principle is in conflict with the concept of optimization:

- If standards are set too high, then HOT lanes will be prohibitively expensive in some places; it will not be possible to build them and so the public will forego their potential benefits.
- But if standards are set too low then agencies would forego the opportunity for best-practice design in places where it can be provided at reasonable cost.

The trade-off between consistency and optimization occurs frequently in highway design (for example in ramp configurations), and this has been an ongoing challenge in the implementation of the region’s HOV lane system. However, such trade-offs have not yet been fully developed for HOT lanes because it takes a few years of testing before the profession settles on the elements of good design. This is not a purely local concern; HOT lanes are being developed in southern California and in other states, so it would be desirable to maintain sufficient consistency that drivers familiar with HOT lanes in one region would recognize what to do when they are in a different region.

The Project Steering Committee examined three levels of design consistency that could be applied to HOT lanes, namely:

- Strict consistency, analogous to the shapes and colors of street signs
- A limited menu of options, analogous the system whereby freeway interchange ramps are chosen from a few basic designs to choose from (loops, slip ramps, etc.)
- A flexible approach similar to the one used in intersection design, where many different configurations are possible (i.e., 3-way intersections, 4-way, 5-way, different angles, roundabouts, etc.) depending on the context.

The consensus view was that attempting to maintain strict consistency would be counter-productive at this planning stage. A better approach would be to try several basic design approaches, see which works best in the field, and then codify the results in the form of design guidance for further project development while always recognizing the importance of the actual geographic context in which a project is developed. However, in the case of signage and lane markings, a greater degree of common standards was desired by the group.

Conversion of Existing or Funded HOV Lanes

The principal mechanism for developing the HOT lane network is through conversion of existing or funded HOV lanes; such conversions would account for 64% of total lane-miles in the regional HOT lane network. Conversions were analyzed in detail in several of the study corridors, resulting in the conclusion that for many areas of the network, the technical task will be relatively easy. Physically what is required would be a 2-foot buffer, the tolling equipment, and the ingress and egress points. In some physically constrained areas adding the buffer, ingress and egress points, could require some reduction in design standards, but on the whole the engineering aspects of the conversion appear feasible with limited complications.

The challenges would be on the policy aspects of conversion. This information did not come out of the technical analysis as much as from discussions with the affected state agencies and Steering Committee members. Some of the policy challenges are highlighted below.

On existing HOV lanes, restricting access or making access changes could adversely impact existing users. Existing users will lose their current right to enter and leave the HOV lanes wherever they choose. This can be politically controversial, as was learned last year on I-95 in Miami[5]. Users will also find the HOV lanes more crowded than they are accustomed to, and even though speeds may not change, there may be a perception of degraded service.

[5] HOT lanes were introduced on I-95 in December 2008 as part of a UPA grant project and in part to generate funding for improved enforcement on what had been a set of poorly-enforced HOV lanes offering continuous access. The initial HOT section opened along 8 miles with no intermediate entry and exit. The first days of operation were marred by drivers cutting through the series of plastic pylons marking the buffer between the HOT lanes and the adjacent general purpose lanes, which caused various accidents. This was due in part to driver confusion caused by the sudden changes restricting access by the placement of pylons over a short period of time. Safety has since improved as drivers have become accustomed to the new access environment.

The conclusion of the study team is that the HOT lanes program must be presented to the public in a way that convinces existing users that the overall impact will be positive. For example, it may be necessary to include physical upgrades such as resurfacing so that existing users see a visible improvement even if resurfacing is not programmed in the same timeframe. Existing users will also benefit through extending the network with greater connectivity between HOV facilities, or through freeway flyovers or other enhancements.

In terms of project timing, the optimal time to convert existing HOV lanes is in conjunction with repaving or reconstruction. That way the electrical conduits needed for toll equipment can be installed beneath the pavement without further affecting traffic operations. Conversion during repaving also eliminates the need for roto-milling and overlaying pavement for re-striping.

In some corridors new HOV lanes are currently under construction or are already set to bid. In such cases it is probably too late to change their designs without causing undo delay to the projects. The best that can be done is to seek ways to limit the cost of retro-fit to HOT standards.

Where lanes are planned but not yet in design, it may be possible to include HOT design features, even if HOT operation is not expected for some time. In this regard it would be beneficial if widely-applied design standards were to be revised so as not to preclude HOT lane operations in the future, even in places not currently in the network. This is consistent with HOV lane foresight practiced over the past 20 years.

Ramifications of Transition Lane Design for Limited Access

The third set of findings relates to the ramifications of including transition lanes in the design of the ingress and egress points (see Figures 2 and 3). The transition lanes are intended to allow drivers a segregated area to accelerate or decelerate to match adjacent traffic. Caltrans District 4 has also specified that ingress and egress movements should take place in separate locations. Transition areas are a standard feature for freeway ramps, but they are not currently used in California for HOV lanes, even where access is limited[6].

[6] Limited-access HOV lanes can be found on freeways in southern California. The access points on these facilities consist of areas where the painted buffer, which is usually a pair of solid amber lines, is replaced by a single broken line.

Caltrans has examined the safety implications of HOV access designs, and has concluded that both continuous and limited-access configurations are safe. The potential added benefits of transition lanes will not be able to be quantified until the I-680 Express Lane has been in service for some time and a comparison can be made.

The transition lanes require 11 feet of additional width for a distance of about 1500 feet, plus over 1000 feet of taper before and after in typical tangent settings. There are further requirements regarding minimum distances from nearby ramps, to ensure adequate space to weave across the GP lanes. These are shown in previous Figure 4.

The physical requirements of transition lanes impose several types of costs on the HOT lanes program. The most obvious are the direct costs of constructing the ingress and egress points, which can be seen in Tables 1 and 2. However, the indirect costs may be as important as the direct costs. One indirect cost stems from the difficulty in finding suitable sites with sufficient space to accommodate access points with transition lanes. A consequence is that fewer sites will be provided and those that are provided might be less well-located than drivers would wish. In some corridors transition lanes may not be physically feasible, leading to questions about whether the full network could be completed if this design is strictly adhered to.

Another indirect cost takes the form of loss of flexibility; the difficulty in placing these access points would essentially preclude adjusting their positions to account for actual traffic patterns or changes over time.

Enforcement Issues

The next set of findings covers enforcement issues. During Phases 1 and 2, the study team felt that the major concern would be the need to provide 14-foot enforcement areas along medians as specified in Caltrans *HOV Guide*. However, during the course of Phase 3, the CHP clarified that its policy is to pull violators to the right shoulder, both for safety reasons and because state law states that drivers should pull over to the right. Therefore, there is no need to provide 14-foot enforcement areas in the median, but there is a need to promote safe enforcement.

Instead, the key enforcement problem is how to detect multiple types of violations---has a single driver paid the toll or not? This can be considered an ITS issue involving on-site presence since cameras cannot determine who should be free for eligible multioccupant vehicles. However, there are various legislative and technological obstacles to a comprehensive ITS solution, and this issue is not unique to the Bay Area or California. Some steps are being taken by other agencies including Caltrans and the San Diego Association of Governments to address some of these obstacles such as Title 21 transponder protocols and technology to help detect occupants in a carpool.

Improved technological options already in use on other HOT lane projects for transponders can more easily communicate to help officers identify which drivers have paid a toll.

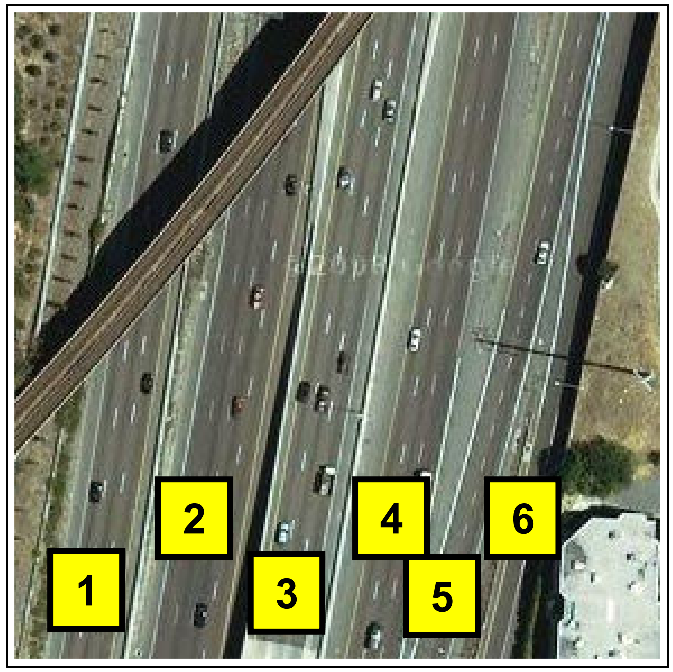
Discussions are currently underway regarding the possibility of expanding transponder capabilities on Bay Area toll facilities either through a re-interpretation or revision of Title 21, and the Caltrans Express Lane Business Plan is anticipated to address these shortcomings with recommendations. This phase of study and Steering Committee discussions noted the current shortcomings of current enforcement practice. Cost estimates do not assume major technology advances to address these issues, but assume a higher level of enforcement presence and an allowance for equipment that could help officers determine active status accounts and recently completed transactions, based on I-680 HOT lane development and related project assumptions.

Highly Constrained Locations

The final set of findings focused on the special issues related to locations with challenging physical constraints. Several of the study corridors, namely I-680 through and north of the I-680/SR-24 interchange (see Figures 6 and 7) and US-101 in San Rafael, were selected in part to provide an opportunity to study these issues.

One finding was that the highly constrained locations tended to coincide with areas of high traffic demand. Quite often the root causes of the physical constraints lie in the fact that the space within the right-of-way (ROW) has already been consumed by previous efforts to satisfy demand and that the ROW cannot easily be widened due to the nearby dense urban development that created the demand in the first place.

Figure 6: Highly Constrained Section of I-680 in Walnut Creek



Portions of I-680 offer little scope for additional lanes, such as the section shown in Figure 6 that already has six carriageways side-by-side, as well as piers from the BART overcrossing (top left of the photo).

Figure 7: Another Highly Constrained Section of I-680

The section of I-680 shown in Figure 7 is constrained by buildings directly adjacent to the freeway on both sides. The Marriott Hotel is the building on the right.

A further technical finding was that allowing design compromises greatly improves the feasibility of HOT lanes in isolated, constrained locations, particularly relaxing restrictions on some lane and shoulder widths. A careful balance weighing trade-offs typically associated with the Project Study Report (PSR) phase is needed to best determine the best fit for these settings.

While the cost of providing HOT lanes in highly constrained locations will be higher than elsewhere, it is also true that the potential benefits and revenues will be higher as well. This suggests that in some corridors a detailed cost-benefit analysis would be needed; high cost may be justified if system-wide benefits are high enough. Such an analysis was not part of the Phase 3 study, but is recommended for the PSR stage.

Another finding from this analysis is that it may not be feasible to provide HOT lanes in the near-term in some locations. In such cases a discontinuity in the HOT lane may be the only outcome until such time as an approach can be determined and environmentally approved to either acquire new right-of-way or build a viaduct. This would be a continuation of the current project development practice for HOV lanes and connectors. Deferring implementation of the most difficult sections would have the further advantage of allowing time to see whether demonstrated operations on I-680 and other new HOT facilities will shed more information about acceptable design trade-offs. And as tolling technology improves, new approaches may be considered along with the likelihood of lower tolling infrastructure and system costs.

5. CONCLUSIONS

General Feasibility of the Concept

The corridor analyses found that, if some flexibility were allowed in the design features favored by Caltrans District 4 (e.g. Revised Full Featured approach), then HOT lanes appear to be feasible over nearly all of the proposed network, or could be phased in more effectively with some interim design exceptions, excepting only a few of the most highly constrained corridors.

The access concept incorporating transition lanes and allowing movements in only a single direction (i.e., ingress or egress) imposes significant affordability, operational and environmental barriers to providing access where and as often as drivers would like. This may cause problems of public acceptance especially where existing HOV lanes are to be converted to HOT lanes. The inconvenience caused by limited access opportunities may also discourage use of the HOT lanes and thereby reduce program benefits. These negative aspects of the design should be closely studied, along with the safety benefits, when the first access types of this kind open on I-680 and other regional corridors.

MTC remains interested in pursuing the Rapid Delivery approach developed during the Phase 2B portion of the study, and consistent with design approaches used in Southern California, for certain areas of the network where the design approaches studied in Phase 3 present significant physical, environmental or financial challenges.

Estimated Cost of Development

The estimated cost to develop HOT lanes throughout the entire network would average $5.4M-$6.2M per lane-mile, or $4.1-$4.5 billion for the entire network depending on the approach used in each corridor. Approximately $1.7 billion (35%-40% of total costs) would go towards the costs of providing transition lanes at access points, and another approximately $650M-$800M (15%) would go towards connector ramps, modifications of existing structures, and other special locations. The remainder would be the cost of the HOT lanes themselves.

Actions Needed to Advance the Concept

Based on studies completed in this phase of work and dialogs created between MTC/BATA and partnering agencies, cost estimates have been refined to inform the Caltrans PSR process and complement ongoing HOT lane development by some partnering agencies.

Future actions include the following:

- Pursuit of selected early action projects based on opportunities associated with pending or programmed construction of HOV lanes and related improvements.
- Development of more refined cost estimates for other portions of the network.
- Evaluation of specific design, technology and operational issues that could alter demand, cost and revenue assumptions applied in network studies performed to date.
- Develop phased HOT Network implementation strategy based on cost, revenue and freeway operational benefits.
- Monitoring of HOT lanes which will be opening within the next several years that could affect current prescribed guidance and standards of practice.